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THE NMC MANPOWER REQUIREMENTS MODEL.(U)
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11 June, 1978

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6 THE NMC MANPOWER
REQUIREMENTS MODEL.

by

MATHECH, Inc.
Dr. J.H. Augusta
Mr. P.E. Hudak

Charlottesville, VA

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Chief of Naval Material, U.S. Navy
Via the Office of Naval Research
Washington, D.C.

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PREFACE

✓ This Final Report Constitutes deliverable A002 under ONR Contract N00014-77-C-0410. The contract involves a study to develop a manpower requirements model for the Naval Material Command, specifically in the area of management and support of acquisition programs. This report describes the overall development of that model and its basic structures. The quantitative estimating relationships which were finally developed are documented; and their use in making manpower projections is discussed.

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The authors also wish to acknowledge the assistance provided by J. Watson Noah Associates, subcontractor in the study. The Noah team was responsible for collection of manyear data from NAVAIR, the NMC R&D Centers, and from SEA-03 and 02, as well as for the final editing and entry of all manyear data into the survey data base.

EXECUTIVE SUMMARY

The primary objective of this study effort was to establish the quantitative relationship between the manpower required to support acquisition projects and the basic characteristics of the acquisition projects which that manpower supports.

This report first summarizes the underlying process of weapon system acquisition and then presents a conceptual model representing the key aspects of this process for the purpose of projecting manpower requirements. Briefly, these aspects are time phasing, organizational participation, functional tasking, and projected characteristics. The conceptual model is presented in terms of an increasingly detailed structure for categorizing manpower, with a particular level of the structure identified as the point where estimating relationships are developed. The estimating relationships represent the quantitative relation between individual project characteristics and the manpower required to manage, develop, design, test, procure, and supervise the construction of new weapons systems.

The estimating relationships have been derived from analysis of manpower data that were collected via a survey.

How the estimating relationships can be used to make projections of manpower requirements is discussed. Related data requirements and model outputs are also specified.

Chapter I

INTRODUCTION

The Naval Material Command (NMC) has the responsibility for managing the acquisition of all ships, aircraft, missiles, and other hardware systems for the Department of the Navy. To meet this responsibility, NMC needs to understand the manpower implication of this acquisition program. In particular, it must estimate future manpower, both civilian and military, necessary to manage these acquisition projects. The estimates must be based upon current and anticipated workload as determined by scheduled ship, aircraft, and missile acquisition programs. To centralize and integrate the estimating process, the Chief of the NMC requested that a topdown model be developed for NMC use during the planning and programming process. MATHTECH, a Division of Mathematica, Inc., was selected to develop this model. The model which resulted from that effort is described in this report in terms of its structure, use, and limitations. Detailed operating instructions are contained in a separate MATHTECH report (NAVMAT 7192-TR-3).^{1/}

^{1/} A programmer's guide is also available. Due to its size and limited audience (useful only to people changing the model's structure) it is not available for general distribution.

A. BACKGROUND

The Naval Material Command (NMC) consists of the Commander (the Chief of Naval Material), Headquarters Naval Material Command (NAVMAT), several separately organized Project Management Offices, five subordinate systems commands (SYSCOM's) and the Navy Research and Development (R&D) Centers. Major suborganizations include system command headquarters, system command field activities such as test ranges, Naval air rework facilities (NARF's), and Naval shipyards, each with thousands of civilian and military personnel. These organizations perform a variety of functions including research and development, testing, production, maintenance, and supply. Procurement of about ten billion dollars to commercial contractors is supervised annually.

Within the system commands, project managers are assigned responsibility for the development and acquisition of specific systems and equipment. Project managers also exist at the NAVMAT Headquarters level for such systems as Strategic Systems (PM-1), Trident (PM-2), Joint Cruise Missile Project (PM-3), and Anti-submarine Warfare Systems (PM-4).

The NMC R&D Centers perform research, development, technical assistance, systems design and integration, and

technical evaluation and management in support of project managers and the systems commands. The NMC R&D Centers include:

- o Naval Air Development Center
- o Navy Personnel R&D Center
- o David W. Taylor Naval Ship R&D Center
- o Naval Weapons Center
- o Naval Ocean Systems Center
- o Naval Underwater Systems Center
- o Naval Surface Weapons Center
- o Naval Coastal Systems Laboratory

B. SCOPE OF PROJECT

The model developed by MATHTECH provides the NMC with a quantitative means for understanding and explaining the manpower requirements of the acquisition functions of the NMC. The model gives the NMC a management-oriented model to determine the manpower requirements for managing ship, aircraft, and missile acquisition programs. The model incorporates a methodology for making systematic manpower projections with a comprehensive data base and responsive software. It was designed to aid decision making at the highest levels of the Naval Material Command, specifically for use in the programming and budgeting process.

The model gives NMC a management capability that other models and data systems do not provide. The SHORESTAMPS

program is designed to provide each line manager at individual work centers with an exact, detailed estimate of the people needed to meet his tasking. On the other hand, the Navy Resource Model (NARM) provides estimates at an aggregate level of the monies needed in the O&MN and MPN appropriations to run the Navy. The NARM has proven to be invaluable in providing an aggregate structure and format for the programming process, and has demonstrated the great importance of the role that top-down models can play in the resource allocation process. However, the NARM has no capability to estimate civilian manning requirements, and therefore a separate but compatible model needed to be developed.^{1/}

The model developed for NMC has a "top-down" structure which begins by computing manpower requirements for the project manager's staff and then, following the imposition of the workload, traces the manning requirements down to the functional support activities and then to the field activities. Thus the structure of the model reflects the process and organizational structures that NMC uses to procure ships, missiles, and aircraft. The model has no more detail than is necessary for top-level NMC managers to justify their programming and budgeting requests.

^{1/} Key members of the contractor team that developed the NAVMAT Manpower Requirements Model were also instrumental in developing the NARM.

C. OVERVIEW OF THE MODEL

The basic objective of the NMC Manpower Requirements Model is to project the manpower required to manage ship, aircraft, and aviation missile acquisition projects. Other acquisition projects, and logistics and G&A manpower are carried as throughput values in the data base. Thus, the model's data base provides an overall, topdown picture of all NMC manpower.

For purposes of the model, the people in the NMC are divided into major categories according to the three functions that they perform.

- o Acquisition
- o Logistics
- o General and Administrative (including Corporate Management)

Acquisition manpower includes all manpower required for managing the development and completion of acquisition projects. Acquisition begins with the conceptual phase (usually when a project manager is named) and continues until the system is no longer being produced or modified in production. Logistics manpower includes that manpower associated with fleet support and include the supply of operational systems with spares and other maintenance-related articles or services. The General and Administrative category includes the headquarters manpower needed by NMC which

is independent of the particular systems being acquired or operated at any given time. This manpower supports all NMC programs including Acquisition and Logistics. It includes the Commander, Vice-Commander, their immediate staffs, special staffs, the Comptroller organization, and the personnel management organization at NAVMAT Headquarters and at the headquarters of each Systems Command.

Acquisition manpower was the category of interest for our modelling purposes and has two parts:

- o Direct acquisition manpower
- o Indirect acquisition manpower.

Direct acquisition manpower is that manpower required to manage the acquisition of new weapon systems which can be directly identified with a new aircraft, ship or individual weapon system. Indirect manpower is the general technical, administrative, and supervisory effort which is necessary to support the direct acquisition effort but which cannot be attributed directly to any individual weapon system.

The model incorporates in a formal, quantitative way the relationships between direct acquisition manpower and the basic characteristics of the acquisition projects which the manpower supports. To make these relationships conceptually more sound, direct manpower was subdivided by function, and a separate estimating relationship developed for each function.

Thus a key aspect of the model is the concept of functional categories. The following functional categories are used in the NMC model:

- o Weapon systems support
- o Technical engineering support
- o Integrated logistics support
- o Test and evaluation support
- o Procurement support
- o Production support.

Functional categories are groupings of acquisition manpower which support acquisition projects based on the general kind of functions performed during the acquisition process. The functions are defined in broad terms and are intended to distinguish major differences among professional or management skills and disciplines. The categories were defined independently of organizational structure; but because the systems commands are structured in somewhat of a functional way, there is a high correspondence between some functional categories and entire organizational units. Other units, however, have manpower that is distributed across several categories.

The reasons for creating functional categories are important to understand. It was clear that better estimating relationships could be developed by categorizing acquisition

manpower by a functional basis because the categories, by definition, are homogeneous with respect to basic tasks performed and hence with respect to measurements of workload. Furthermore, the requirements for manpower in the various functional categories are affected by differing project characteristics. One set of characteristics drives the manpower in a category such as technical engineering and another set of characteristics (of the same project) drives the manpower in procurement (contract administration). Additionally, the manpower requirements in each of the functional categories exhibited different time phasing over the entire acquisition cycle. For example, the manpower required for integrated logistics support planning peaks in the early phases of the acquisition cycle.

The manpower in each functional category is estimated in total (military, civilian, contractor), regardless of organizational source such as headquarter's functional codes, field activities, or R&D centers. The inclusion of contractor support manpower is necessary because civilian and military manpower levels alone have historically been inadequate to handle the acquisition workload.

A Manpower Estimating Relationship (MER) was developed to estimate the manpower required in each functional category for each major kind of hardware system. The MER's relate the

characteristics of acquisition projects to the total direct acquisition manpower required in each functional category. The MER's are in the form of regression equations and are used to project many years requirements for new projects and for existing projects that have new or changed characteristics. This procedure assumes that the project characteristics are implicit measures of workload. The only practical approach for a macro, long-range planning model of this type is to use summary level characteristics that correlate highly with manpower and that can be expected to be reasonably highly correlated with detailed underlying measures of actual workload.

The model provides estimates for major acquisition projects. For the Naval Air Systems Command (NAVAIR), PMA's and APC's are defined as major acquisition projects; for the Naval Sea Systems Command (NAVSEA), PMS's are included that procure ships (but not other weapons systems). The model does not estimate manpower for projects that are not procuring new weapon systems. Examples of such projects are PMA-270 NALCOMIS and PMS-306 Ship Support Improvement Project. Furthermore, the model does not have estimating relationships for activities providing continuing development of component equipment such as ground support equipment for aircraft or sonar for ships. The model assumes that these activities

will have the same manning as last year. There is, however, a provision for the model's user to insert his own values.

The model has the capability of displaying its manpower estimates not only by project and by functional category but also by organization. This organizational breakdown is based on the observed distribution in a base year, at present FY1977. The model does not optimize the distribution of manpower between in-house and contractor sources; nor does it employ any other programmed decision logic to arrive at the displayed breakdown. Our manpower projections include only those manyears of effort required to plan for, manage, and execute major NMC acquisition programs. The manyears expended by hardware contractors in building and deploying the finished product are not calculated nor projected.

In sum, the scope of the model involves the basic projection of direct and indirect acquisition manpower by functional category and the throughput of logistics and headquarters' G&A manpower. For new projects these estimates are initially provided by the MER's. The model utilizes a notional manning curve showing the expected distribution of manpower in relative terms over the life-cycle of a project to project the MER estimates for each phase of the entire acquisition cycle and for each fiscal year.

Chapter II

STRUCTURE OF MODEL

The structure of the NMC Manpower Requirements Model is based upon the acquisition process that NMC uses. To understand the structure of the model it is necessary to understand this acquisition process. Thus, this chapter begins with a discussion and description of the acquisition process; it then goes on to describe the model structure that has been created to represent this process.

A. ACQUISITION PROCESS

The acquisition of aircraft, missiles, and ships within NMC is a complex process with several major phases separated by distinct milestones. The acquisition process is defined by DoD Directive 5000.1 dated 18 January 1977. It prescribes milestones and review procedures for use by the Defense System Acquisition Review Council (DSARC), the activity within the Office of the Secretary of Defense which monitors weapon system acquisition. The major phases in the life-cycle of a weapon system and the corresponding DSARC milestones are:

<u>Phase</u>	<u>Initiating Milestone</u>
Concept-Formulation/Program Initiation	DSARC 0
System Validation/Demonstration	DSARC I
Full-Scale Engineering Development	DSARC II

<u>Phase</u>	<u>Initiating Milestone</u>
Production	DSARC III
Operation	(Not included in Directive 5000.1)

Although the operation phase is not formally part of the acquisition process, it must be included due to the significant amount of new acquisition effort for aircraft projects which is accomplished during the operation phase of the basic system. NAVAIR project offices (PMA's) are maintained while major modifications are performed on the system.

Many acquisition projects currently being managed within NMC had their origin prior to the start of the current DSARC milestone process (approximately 1969). The start and end dates of acquisition phases for these projects were developed by utilizing the definitions given below of the type of effort accomplished within each phase.

1. Concept Formulation

During the early stages of concept formulation, a new operational capability is defined. The particular outputs of this phase include a Mission Element Needs Statement (MENS), and Operational Requirement (OR), and a Decision Coordinating Paper (DCP). For projects starting before DoD Directive 5000.1 was issued, it is difficult to pinpoint the exact start of this phase.

For purposes of the NAVMAT Manpower Requirements Model, we defined the start to be when a program manager or project coordinator was named, or when the MENS was approved. The phase is defined to end with the DSARC I approval.

The resources required during this phase involve heavy support from headquarters organizations (which may draw on the CNM R&D Centers). Very little support, if any, is provided from the field activities during this phase.

2. Validation and Demonstration

This phase begins at DSARC I approval and concludes at DSARC II approval. Outputs include an updated Decision Coordinating Paper (DCP), a preliminary Test and Evaluation Master Plan (TEMP), and a formal program plan including a complete budget by appropriation category. Work in this phase begins with the formulation of a valid plan for satisfying the operational requirements (OR) and selection of the alternative solutions to be analyzed prior to full-scale development. This phase involves analysis and trade-offs of system performance, requirements, cost, government furnished equipment (GFE) versus contractor furnished equipment (CFE), logistics, and testing. Typically two or more contractors are selected at DSARC I and these contractors proceed with actual tests involving advanced development models.

3. Full-Scale Engineering Development

During this phase of development a system is designed which satisfies the program requirement and program plan. Within this phase, detailed analyses of the operational environment are performed; the formal Test and Evaluation Master Plan (TEMP) is completed, the test and evaluations of alternative designs are performed, and a detailed design, including specifications for the selected system, is developed. Additional testing, beyond that accomplished during Validation and Demonstration, is performed on full-scale articles and engineering development models in order to better predict the reliability, quality, operational deficiencies, and logistics requirements. This phase begins with approval at DSARC II and concludes with DSARC III approval. The principal outputs of this phase include production specifications (manufacturing data design package), an update Decision Coordinating Paper (DCP), and prototype units similar to those to be ultimately produced.

The resources required in this phase include nearly every functional code within the respective systems command. The AIR/SEA-03 involvement is not as great because they principally handle RDT&E funds only up through 6.3 funding. There is also heavy involvement by the R&D and engineering centers, particularly those involved in design and testing.

4. Production

This final acquisition phase involves the actual manufacture and delivery of completed systems, subsystems, and components to the ultimate user. While this phase normally includes only production (manufacturing) according to the specifications outlined in the manufacturing data package, many engineering changes are often proposed. Trade-offs in schedules, productions rates, or other manufacturing changes are often made, some resulting in model changes. A specific production contract is usually negotiated on an annual basis with possible options for one or more additional years. This phase begins at formal DSARC III approval and ends with the Navy acceptance of the final unit. The major outputs are aircraft, missile, or ships and documents providing operating and support information.

5. Operation

The operations phase is characterized by the utilization of the ship, aircraft or missiles to carry out the missions of the operating commands. It involves the sustained, integrated logistics support capability such as rework, repair, or modifications of the various systems or subsystems. The operations phase usually begins when the unit or article is delivered and ends when that particular unit is disposed of or removed from the inventory. Acquisition-related functions often occur during this phase for aircraft. Some functions are:

- o Follow-on operational testing
- o Design of modifications and analysis of problems requiring new engineering developments
- o Procurement of modified components.

B. GENERAL STRUCTURE

The primary objective of the modelling effort was to establish the relationship between acquisition manpower and basic characteristics of the acquisition projects which that manpower supports. To place acquisition manpower in the proper context and to provide a comprehensive accounting of total NMC manpower, the following structural relationship was adopted.

$$\begin{array}{rcccc} \text{Total NMC} & & \text{Acquisition} & & \text{Logistics} & & \text{Headquarters} \\ \text{Manpower} & = & \text{Manpower} & + & \text{Manpower} & + & \text{G\&A Manpower} \end{array}$$

This equation applies to the entire NMC, including all its field activities and laboratories. Excluded from the model is Navy manpower that is outside of the Naval Material Command. This refers to such major Navy commands as Chief of Naval Education and Training (CNET), Bureau of Naval Personnel (BUPER), and Operational Test and Evaluation Force (OPTEVFOR). Although the workload, and hence manpower in these commands, is affected by the NMC acquisition program, their manpower resources are not under the control of Chief of Naval Material.

The three terms on the right-hand side of the above equation are defined below.

(1) Acquisition Manpower. Acquisition denotes the aggregation of efforts to develop and produce a major weapons system or ship for use by operating forces. It excludes all operational activities associated with the mission application of the newly acquired weapon system. The process is formally defined by DoD Directive 5000.1 of 18 January 1977.

(2) Logistics Manpower. This major category is composed of those programs, resources, and associated organizational elements involved in supporting the fleet and other combat and support forces. This includes tasks of supplying and maintaining the operational forces.

(3) Headquarters G&A (general and administrative) Manpower.

This term includes those functions and resources associated with managing, administering, and providing services in support of all NMC programs, both acquisition and logistics programs. The particular headquarters elements that are included in this category were determined according to NMC implementation of stratification.

Each category of manpower is composed of the following three labor types:

(1) Military Manpower. Many years of active duty Navy military personnel, including both enlisted and officer personnel. This manpower is funded by the MPN appropriation.

(2) Civilian Manpower. Many years of General Schedule graded personnel who fill positions within the Naval Material Command and who are within activities under NMC command.

(3) Contractor Manpower. Many years of professional and administrative services of private firms or companies that support NMC acquisition programs either directly or indirectly. Such services include performance of studies and analyses, writing of technical reports, preparation of working designs and contract specifications, etc. Many years devoted to actually building the ship, aircraft and missiles is specifically excluded.

Acquisition manpower is the major category of interest for our modelling purposes, and is represented as:

Total Acquisition Manpower	=	Direct (specific) Manpower	+	Direct (common) Manpower	+	Indirect Acquisition Manpower
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Each of the terms on the right side may be split on the basis of being variable (or not) with respect to measurements of acquisition workload. Direct (specific) includes both the

project managers that are being modelled and project managers that are being throughput, as well as all other functional and field activity manpower that can be attributed to each particular project. The project managers that are modelled have a portion of their manpower that is fixed. The terms direct (specific), direct (common), and indirect manpower are defined below.

(1) Direct (specific) Manpower. This is the effort that is required to conceptualize, analyze, design, develop, test, produce, and deliver major new weapon systems and that can be directly identified with a specific weapon system.

(2) Direct (common) Manpower. This is the effort that is required to conceptualize, analyze, design, develop, test, produce, and deliver major new systems and that can be directly identified with several (but not all) weapon systems.

(3) Indirect Manpower. This is that general technical, administrative, and supervisory effort which is necessary to support the direct acquisition effort.

Clerical and administrative effort may exist in each of the above categories. The extent to which such effort can be attributed to particular acquisition programs determines its categorization. Thus, for example, clerical and

administrative effort expended immediately within a particular project is considered direct (specific).

Both direct and indirect categories of acquisition manpower are further divided into functional categories. The direct manpower, i.e., the direct (specific) and the direct (common), are broken into functional categories at the individual weapon system level. Indirect acquisition manpower by definition cannot be identified to any particular new ship class, and thus, is broken out by the functional categories at an aggregate level. The functional categories are explained below.

Functional Categories. These are groupings of acquisition manpower that support acquisition projects and are based on the general kind of function performed during the acquisition process. The functions are intended to distinguish major differences among professional or management disciplines utilized during the acquisition process.

The following functional categories were defined for modelling manpower that supports acquisition projects:

- (1) Weapons Systems Support
- (2) Technical Engineering Support
- (3) Integrated Logistics Management
- (4) Test and Evaluation Support
- (5) Procurement Support
- (6) Production Support.

These categories apply to all acquisition-related manpower (i.e., both direct and indirect), except for many years explicitly identified to be in the acquisition project offices themselves. The project management offices form their own special manpower category; thus the six categories above include manpower supporting the acquisition process at NAVAIR and NAVSEA functional codes (i.e., the functional matrix, NAVAIR and NAVSEA field activities, R&D Centers, other Navy activities and contractor support).

Each functional category is described in turn below.

(1) Weapons Systems Support. This category includes those personnel who perform financial management to support the budget as well as other tasks relating to planning and programming. These tasks can directly support particular project managers or can support the acquisition effort in general. This category also includes those personnel outside of the project office who are responsible for overall project administration and progress reporting. Also included are personnel who conduct risk analyses and cost studies.

(2) Technical Engineering Support. This is a broad category that includes personnel having a common skill denominator of engineering expertise and technical management. More specifically, it includes those personnel who either manage, directly lay out or evaluate

system designs and specifications. Such materials include management and technical plans for subsystem integration and installation. The category also includes personnel who formulate technical requirements and monitor the technical performance of manufacturers. Additionally, it includes those personnel who conduct threat analyses and who interpret such analyses with respect to technical system performance requirements.

(3) Integrated Logistics Management. This category includes those personnel who plan for and integrate into the system design considerations of logistics support. This includes planning and evaluation of both maintenance and supply concepts as well as policies regarding personnel manning and training. Also included are personnel who prepare plans and procedures that support the actual introduction of the new system into the fleet.

(4) Test and Evaluation Support. This category includes those personnel who plan for, monitor, and execute the testing and evaluation of each new weapon system. The actual testing and evaluation is conducted to determine system or subsystem performance, maintainability, reliability, etc. with respect to design specifications and required mission criteria. Depending on the acquisition phase, T&E can involve the extensive

laboratory testing of trial components, actual flight or range tests of complete operational prototypes, or quality control testing of production items.

(5) Procurement Support. This category includes effort directly related to the execution of a contracting strategy for the acquisition of weapons systems and services. It includes functions such as contract preparation and negotiations; contract modifications; legal monitoring of contract performance; and claims analysis and settlement.

(6) Production Support. This category includes those personnel who plan for and monitor the actual manufacture of new weapon systems. This includes such production management tasks as scheduling, adherence to design specifications and quality control procedures, coordination of subsystem integration, standardization of components and parts, appraisal of facilities and industrial management capabilities of manufacturers. The category also includes those personnel who are specifically responsible for planning, monitoring, and controlling the use of Government Furnished Equipment in new ships or weapon systems.

Rationale for Functional Categories

The primary objective of the modelling effort was to establish the relationship between direct acquisition

manpower and basic characteristics of the acquisition projects which that manpower supports. It was assumed for both the ship and aircraft models that development of these relationships would be conceptually more sound if the direct manpower were sub-divided by function and a separate estimating relationship developed for each function. The rationale for this approach was based on two preliminary observations:

(1) Different characteristics affected the requirements for manpower in the different functional categories. That is, one set of characteristics drives the manpower in a category such as, technical engineering; and a different set of characteristics (of the same project) drives the manpower in procurement.

(2) The manpower requirements in each of the functional categories exhibit different time phasing over the entire acquisition cycle. For example, manpower required in connection with ILS planning and production management occurs in and peaks towards the latter phases of the cycle; technical engineering and weapons system support peak (or at least are relatively higher) in the early phases.

To put all acquisition manpower into one category, without any distinction by function, would fail to represent

these basic aspects of manpower requirements. The model would not be able to track these categories separately; it would be based on the tenuous assumption that the relative significance and distribution of manpower among functions and over time remains constant. Also, the less significant types of manpower in terms of many years, but yet of high interest in terms of special professional disciplines or critical contribution to the acquisition process, would be driven in the aggregate by the characteristics of the dominant functions. This would be too aggregate for NAVMAT or the SYSCOM's to accept.

Furthermore, the approach would lead to seriously imprecise projections for manpower requirements given the fact that there has been great variability in the nature of current and historic acquisition programs. There is every likelihood to expect that future programs will have as much variability in the way they are managed and in their mix and phasing of manpower requirements. The model had to be structured in a way that would enable capturing the most important of these potential shifts, while at the same time being independent of purely policy-determined aspects such as organizational structures.

C. MANPOWER ESTIMATING RELATIONSHIPS (MER's)

A Manpower Estimating Relationship (MER) was developed for each functional category of direct acquisition manpower,

MER's 1 through 6. A separate MER was developed to estimate the manpower in project offices, MER-0. That MER was developed from analysis of the currently existing NAVSEA and NAVAIR project offices. MER-0 explicitly takes into account the number and different nature of new weapon systems that are managed by each project office.

Three sets of MER's were developed, one each for aircraft projects, ship projects, and missile projects. Each set has seven equations in it, covering MER's 0-6. The equations account for the difference in ship and aircraft acquisition projects by having different drivers in the air equations than the ship equations and, of course, the values of the coefficients differ.

The manpower in a functional category is estimated in total, i.e., military, civilian, contractor; regardless of organizational sources. Because the manpower in any given functional category typically came from several organizational sources, our estimates are not easily compared to those produced by individual organizational entities within NAVSEA or NAVAIR. To the extent that any of the functional categories are composed of manpower from only one organizational component or activity, it was possible to incorporate some of the features of that activity's manpower planning procedures into our MER's. For example, SUPSHIP's manpower

constitutes 90% of the functional category of production, and because SUPSHIPS uses SCN progress payments as their current manpower planning factor, then annual SCN expenditures for each ship class appears to be a reasonable macro driver of the manpower in that functional category.

The MER for each functional category relates the characteristics of the acquisition project to the total manpower required in the functional category. In this procedure the project characteristics are assumed to be implicit measures or indicators of workload; the true underlying measures of workload, such as number of people to be supervised, number of memos or documents to be produced, number of briefings to be prepared, number of tests to be performed, etc., are much too detailed for a model like this to include. Furthermore, data on such workload measures were non-existent. The only practical approach for a macro, long-range planning model was to use summary level characteristics that correlated with true measures of workload. However, high correlation between manning and summary project characteristics by itself was not sufficient for accepting those characteristics as causative determinants of manpower. The correlative relationship had to be evaluated with respect to criteria derived from an understanding of what the true workload measures may be and what the significant causative drivers of manpower are. This is especially important in an environment that is so

extensively affected by Navy management practices and policy decisions, in addition to a broad set of externally imposed constraints and factors, i.e., from OPNAV, OSD, Congress, etc.

The following characteristics were selected after consultation with NAVAIR experts as being the primary determinants of manpower requirements:

- RDT&E Funding
- Total Funding
- DSARC Milestones
- Number of Contracts
- Number of Models
- Number of Foreign Military Sales Countries
- Number of Production Sites
- Number of Modifications
- Number of Non-USN Users
- Number of Production Units
- Unit Cost
- Joint Project Information
- Number and Cost of GFE Items
- Number of Field Activities Involved.

For ship acquisition projects (PMS's) the following characteristics were selected (again based upon consultation with NAVSEA):

- Number of FMS Users
- Number of Ships to be Built
- RDT&E Funding
- Total Funding (SCN + RDT&E)
- SCN Minus GFE, in millions of dollars
- Dollar Value of Government-furnished Equipment
- Number of Shipyards
- Experience of Shipbuilder
- Number of Major Contractors
- Number of Major Procurement Contracts
- Ship Full Load Displacement
- Ship Length.

In addition to the above characteristics, it was also felt that a significant amount of manyears were driven by the complexity of the system under development. For that reason a qualitative complexity ranking was collected for each new ship class on a one-to-five scale (where one was defined as very low and five very high) and on a one to eighteen scale for aircraft. The expanded scale was shown to be necessary for statistically determining the difference between aircraft projects.

D. NOTIONAL MANNING CURVES

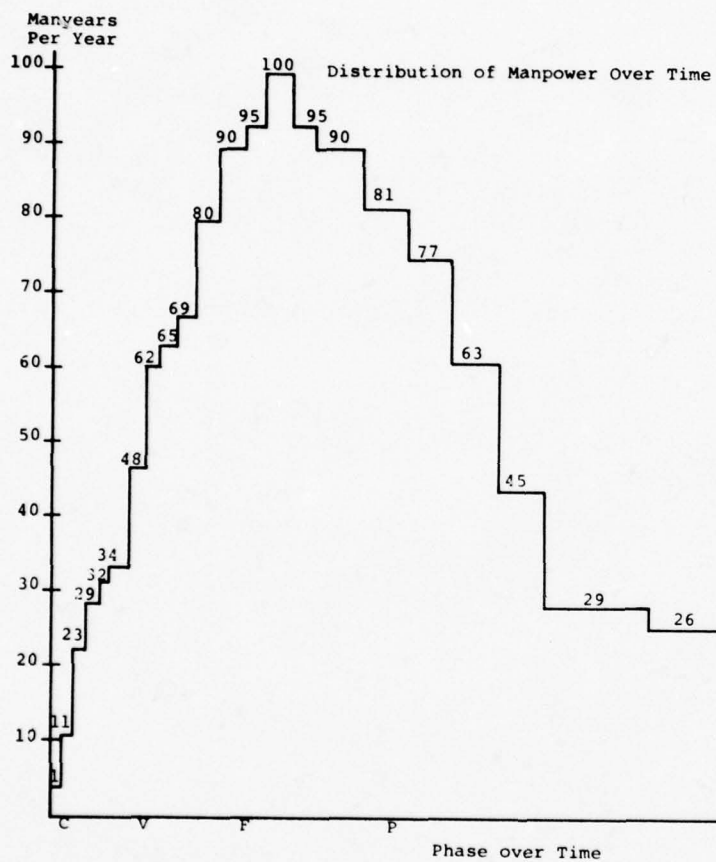
A key aspect of the acquisition process and, hence, of the model, is the variation in manpower requirements with respect to the acquisition schedule. Not only do the types and levels of manpower change from phase to phase but also they change within each given phase. This is primarily due to the changing mix of management and technical tasks within each phase, as well as to the length of some of the phases.

It was important to describe the time dependency of manpower in quantitative terms to provide a means for the model to make outyear projections. (The MER'S are designed to estimate manyears of support at a moment in time.) The lack of complete and accurate historical data on manpower supporting individual acquisition programs necessitated a special approach to this part of the model's design.

This approach involved conceptually defining notional manning curves, and then the collection of judgmentally based estimates to specify the curves quantitatively.

A notional manning curve shows manpower required to support a project as a function of where the project is in its acquisition cycle. The manpower is represented in relative units; that is, the manpower for some particular time interval is arbitrarily assigned a value of 100 and the manpower for all other time intervals is expressed relative to that reference. Those manpower values can be either less than or greater than 100. The time dimension is expressed in discrete intervals (or subphases) which are defined as one-fifth of each respective acquisition phase. A hypothetical notional curve is shown in Figure II-1. In that figure the fourth subphase of the overall full-scale development phase has been taken as the reference interval (100).

To obtain these notional manning curves, it was necessary to obtain estimates on how manning is distributed over the acquisition cycle by functional categories. These estimates were sought from experts within NAVAIR and NAVSEA. These individuals were senior civilian and military managers with many years of experience in the acquisition process or with command practices regarding manpower management. These experts were asked to consider a typical aircraft or ship



Notional Manning Curve

Figure II-1

acquisition program. They were asked to provide three types of information related to acquisition manpower requirements:

- (1) The comparative amount of total manpower among entire phases,
- (2) The distribution of manpower across functional categories within each phase,
- (3) The distribution of total manpower across years within each phase.

They were not asked to make absolute estimate of manpower required, only relative estimates. The information collected was used to calculate a general or standardized distribution of manpower requirements over time for the manpower in each functional category.

The notional curves can be used with two other sets of data to make manpower projections. Those sets of data are (1) absolute manyears (either actual manyears as reported in a survey or estimated manyears produced by a MER), (2) an actual acquisition schedule stated in terms of the dates (month and year) of the major DSARC milestones and of the end of production. Given such "calibrating data," the standard notional curve can be used to provide manyear projections by phase and fiscal year for each functional category for each new weapon system.

E. MANPOWER DATA BASE

The third key component of the model, along with the MER's and notional manning curves, is the Manpower Data Base. The manpower data base is a manpower management information system which allows users of the model to have immediate access to manpower information on many years of support by projection by organization. There are three parts to this manpower data base:

- o Aggregate Data
- o Survey Data
- o Model Projections.

The reader should understand that the first two items are not estimates made by the model; they are information on manpower developed by other systems and assembled here.

The first part of the manpower data base is called the aggregate data base. This consists of onboard strengths by UIC for all people assigned to the Naval Material Command. This data base was assembled from existing MIS systems. For civilians the PADS system was used, which is the manpower reporting system operated by the Office of Civilian Personnel (OCP) that covers all civilians in the Naval Material Command. For information on the military personnel in the Command data files supplied by BuPers were used. What the aggregate data base provides is something that NMC did not previously have -- an integrated management information

system accounting for both military and civilian manpower. Reports from this data base show the distribution of people by organization and by major function, logistics, acquisition and G&A within the Naval Material Command. Immediate access to this data base is provided via remote access terminals. Current plans call for monthly updating of the civilian data base and quarterly updating of the military data.

The second part of the manpower data base is what we call the survey data base. This information is many years of support by major acquisition projects by organization. This information on many years of support covers all support given to projects. Thus, it includes not only project office manpower which is a small part of total manpower supporting projects but also many years of support from NAVAIR and NAVSEA Headquarters organizations, NAVAIR and NAVSEA field activities, and Navy Laboratories. This support covers in-house civilians, military and contractor support provided to each project. Thus it is a comprehensive accounting of total support provided to projects broken down by organization (as designated by UIC). MATHTECH obtained this information via a survey. The survey data base is a comprehensive accounting of all acquisition manpower by project and organization for FY77.

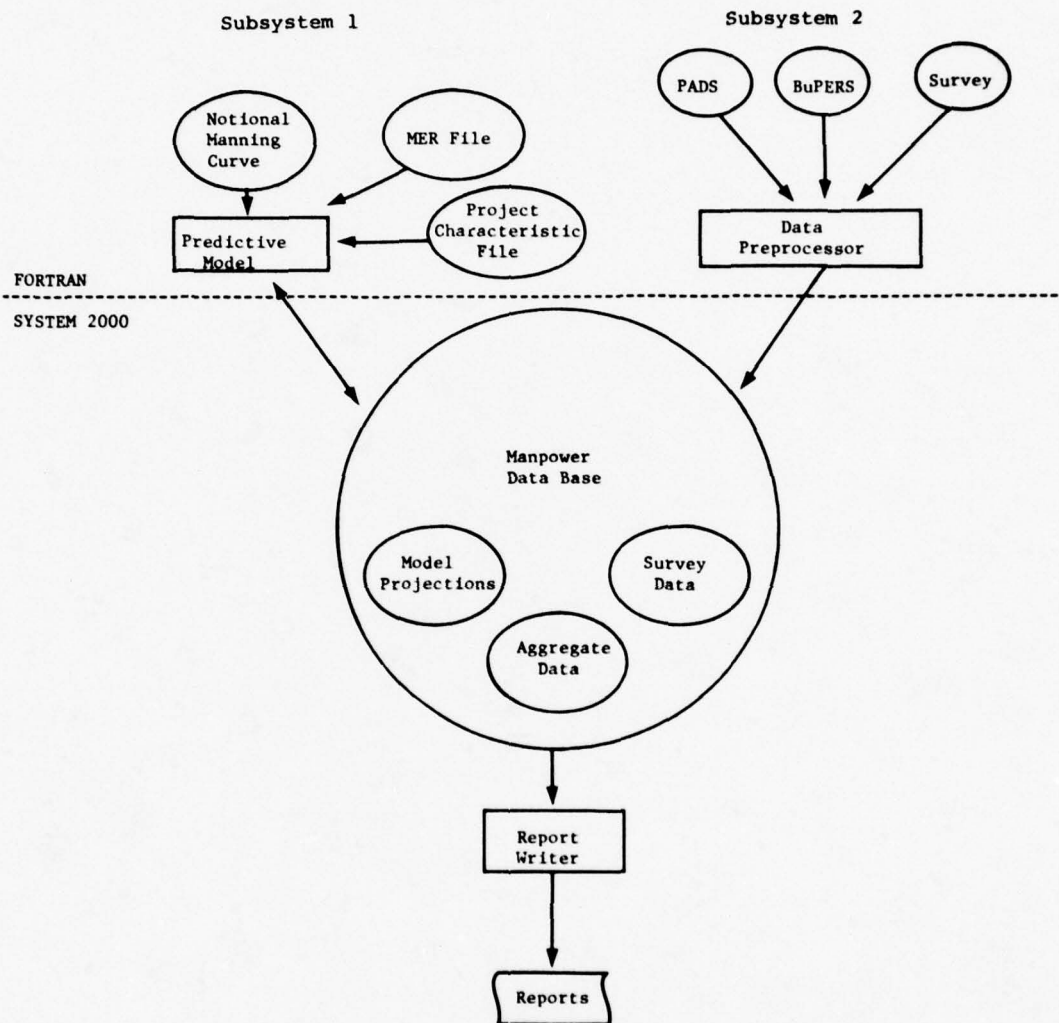
F. COMPUTER MODEL

The analytical tools described above (MER's, notional manning curves and the manpower data base) are combined into one integrated system by the computer model that has been developed. The three major subsystems of the computer model, as shown in Figure II-2 are:

- o The Predictive Model
- o The Data Preprocessor
- o The Report Generator.

As shown in Figure II-2 the NMC Manpower Requirements Model system consists of three subsystems linked by the manpower data base containing all manpower related data.

The first subsystem, the predictive model, is used to estimate the manpower required to manage the acquisition of aircraft, missiles, and ships. As previously described, the predictive model uses the Manpower Estimating Relationships (MER's) to transform independent variables describing characteristics of proposed or existing acquisition projects (project characteristics) into manpower requirements in terms of the six functional categories. These manpower estimated by functional category are then apportioned over time using the notional phasing relationships between manning levels and development phases. In addition, estimates within each functional category may be allocated to individual activities



Subsystem 3
Model Design
Figure II-2

(i.e., UIC's) and labor types (i.e., civilian, military, or contractor) using historically based percentage distributions, derived from the survey data base.

The predictive model is written in FORTRAN. The user converses with the model and enters project characteristic data interactively. The predictive model then uses the stored regression coefficients, notional manning curves, and data on project characteristics and DSARC schedule (characteristic file), and allocation percentages necessary to allocate projected manning requirements across UIC's and labor types (allocation files).

The manpower data base (MDB) into which the predictive model writes its estimates is created and maintained using the System 2000 Data Base Management System. The MDB consists of the two separate data bases discussed earlier: the aggregate data base containing aggregate end-strength data for all persons under NAVMAT cognizance and the survey data base containing manyear data by project. Within the aggregate data base, manpower records created from PADS and BUPERS data tapes contain either information allowing splits into Acquisition, Logistics, or G&A categories, or records allowing grade and occupation code splits. Records within the survey data base include data to allocate projected manning across UIC's and labor types.

The aggregate and survey data contained in the MDB is updated via the Update Processor. This subsystem, written in FORTRAN, accepts civilian end-strength data from PADS, and military end-strength data from BUPERS on a periodic basis. It aggregates this data, allocates it to acquisition, logistics, and G&A categories, and enters the resulting data into the data file. The Update Processor is also used to enter new manyear data derived from acquisition project surveys.

The remaining subsystem allows the user to access and display the manning data in ways which satisfy his analysis needs. There are two parts to this system: the immediate access module and the report writer. The immediate access module is a System 2000 feature which allows quick, direct access to the data with somewhat limited formatting capabilities. This module should be used to answer ad hoc questions where elaborate formats are not required. The report writer, also a System 2000 software package, permits more complex formats but requires that the user spend more time structuring his report request. A set of tailored reports (stored as Report Files) have been written to satisfy many of the known NMC analysis requirements, and this set can easily be expanded as other requirements are identified.

This chapter described the general structure and the various components (MER's, notional phasing curves, manpower data base and computer model) of the NMC Manpower Requirements Model. The next chapter describes the model's use.

Chapter III

USE OF MODEL

A. OVERVIEW

The preceding chapter discussed the structure of the NMC Manpower Requirements Model. This chapter will discuss how the model can be used. The discussion has been generalized because the model is a new tool for NMC staffs; thus, the discussion centers on how the model can be used rather than reporting on specific applications.

There are two basic uses to which the model can be put. The first, and probably a common and frequent use, will be to use the Manpower Data Base to provide reports on the whereabouts and functions of the people in the Command. The second use is to make manpower projections. Because the importance and method of use is self-evident in the first case, no examples or discussion are necessary; this chapter will concentrate on discussing the second case, using the model to make manpower projections.

To understand how the model can be used to make projections, the reader must understand that the use of the equations is independent of the use of the notional manning relationships. The equations estimate manpower for individual projects; these estimates are then summed over all projects to derive total acquisition manpower. Once there

is an acceptable manpower estimate for a project or set of projects (whether derived from the equations, last year's manning level, or someone's best guess) the notional manning curves can be used to make estimates by fiscal year, phase, or acquisition cycle. This is true whether the base estimates are for a fiscal year, phase, or acquisition cycle; the notional manning curves can be used to go from any one of these to any other. Therefore, given an acceptable manpower estimate,^{1/} that estimate and the notional manning curves completely determine the manpower requirements for all phases of the project.

B. THREE CASES

An analyst can use the model to make manpower projections for three basic cases.

Case 1: An existing acquisition project with no change in project characteristics or schedule. This case is the first and simplest; it requires no use of the MER's. Given a DSARC schedule in FY77 manpower (from the survey for FY77) the acquisition cycle manning is completely determined.

^{1/} The manpower estimate for an existing project is currently based on survey results for FY77. For new projects, the equations are used to estimate full scale development (FSD) manpower, which can be converted readily to fiscal year figures.

Case 2: An entirely new acquisition project. This case involves a new project that did not exist for the 1977 survey. Here the DSARC schedule will yield the notional curve; but the model employs the equations to locate one point on the curve from which can be determined all others.^{2/}

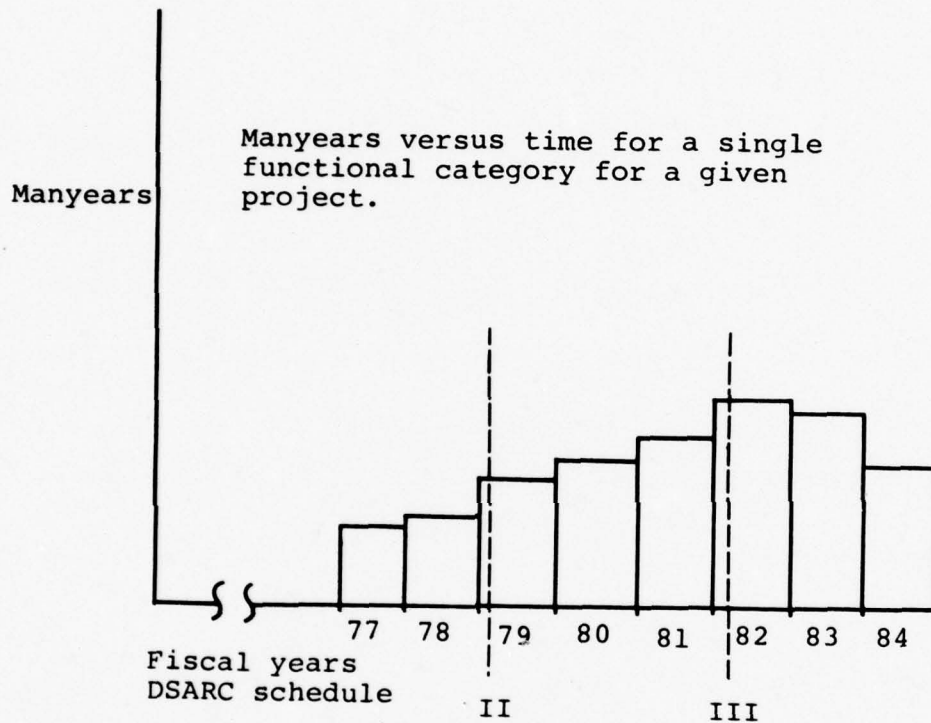
Case 3: An existing acquisition project with (a) changed project characteristics, and/or (b) a changed acquisition schedule. The effect of changing the project characteristics is to cause different manpower requirements in the base year. In essence the notional manning curve undergoes a one-time shift during the fiscal year when the characteristics change takes place. From then on the manpower requirements for that project are completely determined. If the DSARC milestones dates also change, then in addition to the shift of the curve caused by the changed characteristics a new notional curve is appropriate.

These cases have been listed in order of increasing computational complexity and are explained in turn below.

^{2/} Two different sets of equations are probably appropriate. One to estimate total manpower for new projects using drivers that are included for a priori reasons. A second set of equations may be more suitable for altering manpower requirements for existing projects. However, only one set of equations was derived for the initial model due to the paucity of valid data.

In the first case where there is no change in project characteristics, out-year estimates can be computed by using a base estimate for manpower in some given year, the milestone dates of the respective acquisition schedule, and the appropriate notional manning curve. In this case, it is not necessary to use the MER's; the base estimate completely includes the effect of project characteristics on manpower. Figure III-1 illustrates this case. The FY77 manpower is known; its correspondence to the DSARC milestones has been specified; and the appropriate standardized notional curve has been selected and calibrated to pass through the base estimate. Computationally within the computer program of the model, this last step is quite involved. As noted in previous chapters, the notional curve is defined in terms of arbitrary length subphases. For this particular ship class and functional category the computer program effectively converts the generally defined curve to one expressed in fiscal years by means of reference to the actual schedule.

The general approach to Case 1 assures that the out-year estimates are consistent with the base estimate and eliminates introducing into the projected estimates any statistical variation that is due to the intrinsic variability of a generalized MER derived from a sample of several projects.



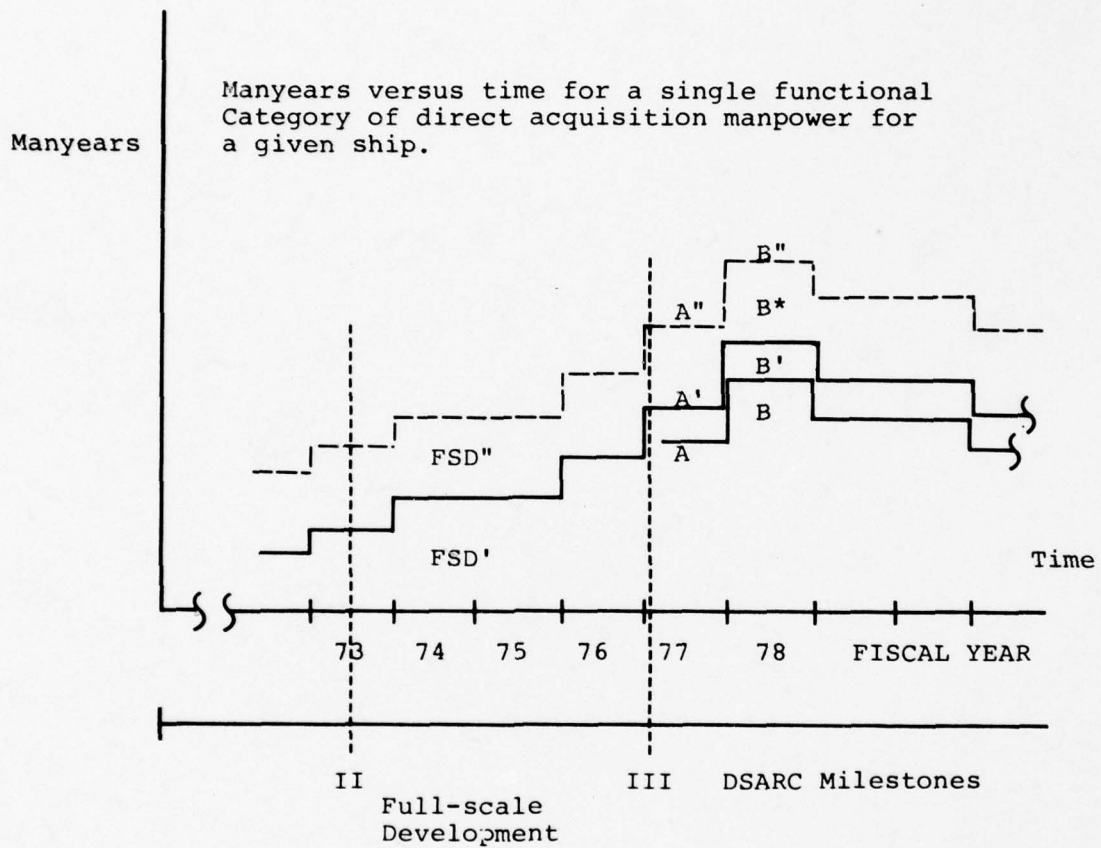
Example of Case 1 Estimates

Figure III-1

In Case 2 no base estimate exists initially; therefore, an MER is used to compute the manyears for an entire pre-selected reference phase. (Normally, the reference phase is full-scale development.) Once the manyears for the reference phase have been computed, the appropriate notional curve is used to compute estimates for the other phases and subphases. The actual DSARC schedule is then used to convert subphase estimates to fiscal year estimates.

Excluding for the moment the effect of changing the DSARC schedule, the third case employs an approach that is a combination of computations employed in cases one and two. Figure III-2 illustrates the basic procedure, where the lettered data points have the following meanings:

- A : actual manyears in FY77
- A' : manyears which would have been estimated for FY77 if the MER with the old project characteristics were used.
- A" : manyears which would have been estimated for FY77 if the MER with the new project characteristics were used.
- B : manyears which would have been computed for FY78 if there had been no change in characteristics.
(This is simply Case 1.)
- B' : manyears which would have been estimated for FY78



Case 3 - Comparative Examples

Figure III-2

if the MER had been used with the old set of characteristics. (Similar to Case 2.)

B" : manyears which would have been estimated for FY78 if the MER had been used with the new set of characteristics. (Another occurrence of Case 2.)

B* : the final estimate of manyears actually computed for FY78.

In this example, it is assumed that the change in characteristics should result in an increase in the manpower estimate for FY78. The estimate finally made for FY78 is computed as follows:

$$B^* = B + (B'' - B').$$

If, on the other hand, a change in characteristics were made in such a way as to produce a decrease in the manpower estimate, the above equation for B* applies so long as B is greater than (B' - B"). That is, B* is not allowed to be less than zero.

B' was computed via the MER using the old characteristics, thus an intermediate result of the calculation was total manyears in the reference phase (denoted by FSD'). A similar derivation pertains to the calculation of B"; FSD" is the analogous estimate of reference phase manyears based on the new project characteristics.

An alternative to the constant rate approach was considered but rejected; namely, that the total manyears of a phase (i.e., the area under the notional curve) was constant with respect to subsequent changes in phase lengths. This would have led to fluctuating annual manyear rates, which was thought to be an undesirable and unrealistic result.

In use, the model first checks the project characteristics. If the project characteristics have changed, the equations are used to reestimate FSD manyears. It then converts these FSD requirements to fiscal years, by way of the notional curves, to obtain an estimate of the manpower required in the fiscal years under consideration. Prior to using the model for a few years, it is impossible to predict the proportion of projects that will undergo changes in their characteristics from year to year. Except under unusual circumstances, one would expect that the manpower changes due to a project changing phase and subject phases (movements along the curve) would swamp those due to changes in project characteristics (shifts in the curve).

C. SEQUENCE OF CALCULATIONS

The previous section discussed the logic of how projections are made. This section describes how and what the user would do to make projections. The projections are accomplished in the following steps:

A variation of Case 3 occurs when there is a change in the acquisition schedule. This is expressed in terms of new DSARC milestone dates that represent either the advancement or deferral of the milestones. The modelling of this effect is independent of the change in characteristics used in the MER's and, therefore, will be described assuming that there is no change in the characteristics.

Specifically, when a new phase length differs from the original phase length, it is assumed that the annual manyear rate computed over the affected subphases from the original schedule remain constant. These rates are then multiplied by the revised absolute lengths of the subphases to provide manyear estimates. It seemed reasonable to assume that lengthening of a phase is likely to result from an increase in the scope or complexity of the project and that this would produce an increase in both workload and manpower requirements.

Conversely, if a phase is shortened and all other characteristics remain unchanged, the model will project a lower manpower requirement. On an annual basis the manyear level may or may not be lower than the original level, depending on the actual length of the phase and the absolute extent by which it was shortened.

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C. SEQUENCE OF CALCULATIONS

The previous section discussed the logic of how projections are made. This section describes how and what the user would do to make projections. The projections are accomplished in the following steps:

(1) The user of the model specifies the new characteristics of the acquisition project, i.e., the size, complexity, etc.

(2) The user specifies the DSARC milestone (or equivalent) dates, and project office (new, existing, undesignated) that will manage the project.

(3) By using the MER's, the model computes the total manpower required in the project management office and in each functional category to support the project in a given phase.

(4) Then a time phase distribution is performed to obtain the manpower required for each DSARC phase.

(5) The phase based estimates are converted to fiscal year estimates according to a simple time proration. At this point, aggregate manpower reports can be generated for the given acquisition project.

(6) To permit displays of manpower by type of labor (military, civilian, contractor) and by organizational source, allocation of the aggregate manpower estimates are made based on some selected base year. That base year data is the latest actual year (currently FY77) and resides in the model's data base as survey data. Each of the steps summarized above is described in detail below.

Input of Basic Characteristics. The user is required to specify as input to the model the basic characteristics of

each acquisition project he wishes to project. There is one set of characteristics for each modelled project in the total acquisition program during the period FY77 through FY85. The characteristics of the projects used to develop the MER's are, of course, readily available. The characteristics of newly emergent acquisition projects, however, will have to be obtained by the user from appropriate NAVMAT, NAVSEA, NAVAIR authorities. Because the MER's were constructed with this requirement in mind, the additional data should be readily available at least in some estimated form. The quality of estimated characteristics would be expected to improve as the new projects mature or as the scope of the projects become more firmly defined for each POM cycle.

In an operational sense, the characteristics comprise a special input file that resides permanently in the general data base. This entire file is identified by a single title and can be accessed in its entirety by the model. Revisions, deletions, or additions of characteristics can be made either to the permanent file or on a temporary basis via the computer terminal for a single run of the model.

Specification of Milestone Schedule. The general points just discussed for project characteristics also apply to the specification and input of the milestone schedule for each weapon system to be modelled. The model logic has been built

on the basis that these milestones are defined as the DSARC milestones (i.e., 0, I, II, III, and the date of delivery of the last unit). For projects not having a formally designated DSARC schedule, equivalent milestones have to be provided by the user. Again, projects that were used as a basis for developing the MER's already have their DSARC or DSARC-equivalent milestones available in the initial data file.

MER Computations. The projection computations for MER-0 (Project Officer Manpower) are described later. The other six MER's for direct acquisition manpower operate at the weapon system level. From the total set of inputted project characteristics of a particular system, each MER produces an estimate of total civilian, military, and contractor manyears that are required for a single, pre-selected phase of the overall acquisition cycle. Estimates of total manpower by functional category for the other phases are then computed relative to the respective base phase.

Time Phase Distribution. With the computations still at the level of weapon system, the estimate of total manyears for the complete reference phase for a given functional category is distributed for the other phases and subphases by use of the notional manning curves. This produces a manyear rate (i.e., manyear per year) over each subphase.

These subphase estimates next are converted to fiscal year manyear estimates.

Conversion of Phase Estimates to Fiscal Year Estimates.

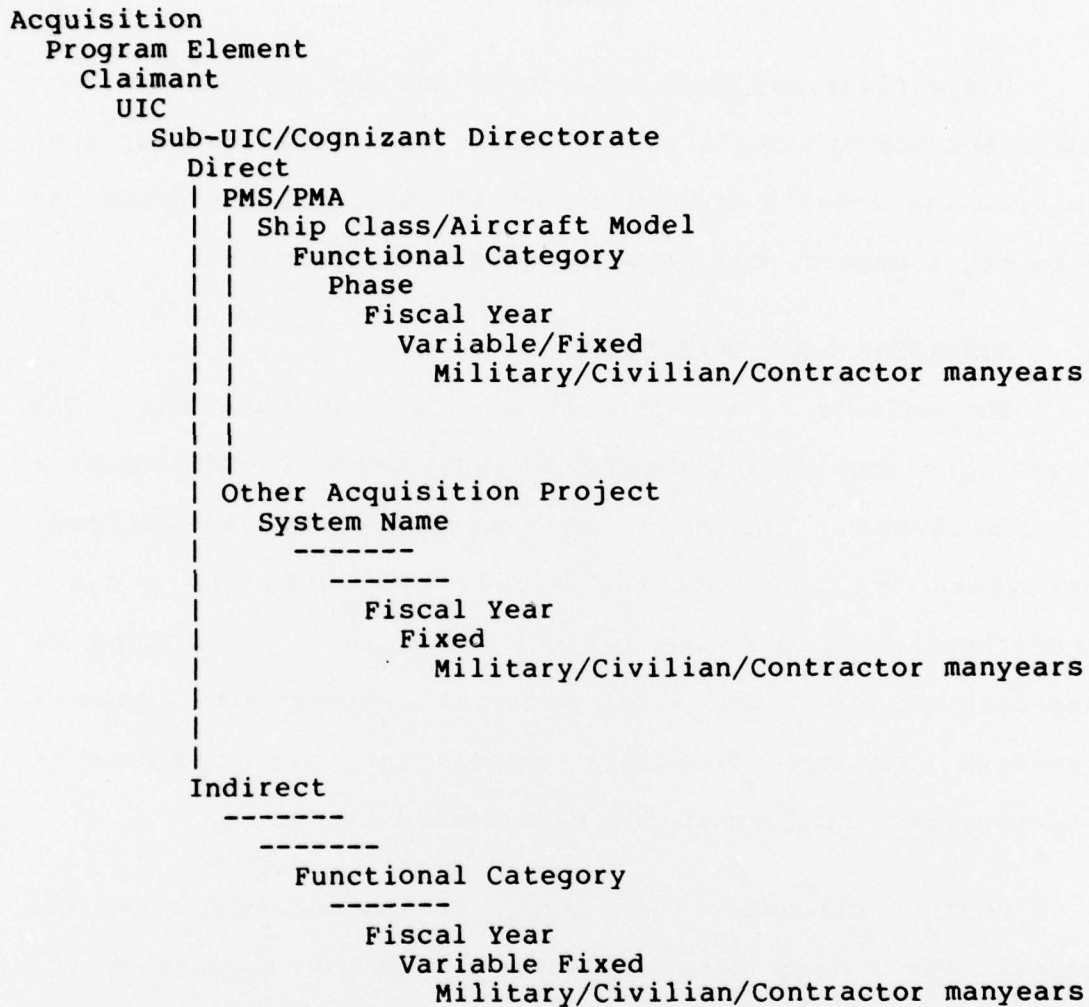
The estimates of total manpower by functional category by fiscal year for a particular weapon system are aggregated with similar estimates for all other systems to produce estimates to total, direct acquisition manpower by functional category. These aggregated estimates are then used as independent variables in an equation that computes variable, indirect acquisition manpower by functional category. Variable indirect manpower is simply proportional to aggregate direct manpower as determined from base year relationships. The variable part is added to a throughput amount to produce total indirect acquisition manpower.

Throughput indirect manpower is specified and input to the model at the PE-UIC level of detail, and then aggregated to the functional category level to produce a corresponding term that can be added to the direct manpower estimates. This allows generation of summary reports with the total acquisition manpower estimates arranged by fiscal year and by functional category.

Allocation of Total Acquisition Manpower Estimates to POM Display Classifications. For purposes of POM development, it is necessary to display the acquisition manpower

estimates by Program Element (PE) and by Unit Identification Code (UIC), as well as by military, civilian and contractor types of labor. This is accomplished by performing a straightforward linear proration based on the historic distribution of manpower among the classifications of interest during a selected base period, e.g., the current budget year. This part of the model, therefore, has access to a manpower data file which is structured similar to and at the finest level of detail that is used to display projected manpower estimates. For acquisition manpower the required level of detail can be represented as a hierarchial set of classifications shown in Figure III-3. Once the estimates have been broken down into the appropriate detailed classifications, they can be displayed by the model's report generator.

FIGURE III-3



Hierarchical Classification of Acquisition Manpower

Chapter IV

SUMMARY

The earlier chapters have described the structure of the model and how the model can be used. This final chapter summarizes the model's strengths and limitations, discusses its data requirements, and proposes possible extensions.

A. STRENGTHS AND LIMITATIONS

The model's first strength is its most important. The model ties acquisition manpower requirements to MNC acquisition programs. The model does this because its manpower estimates are based on the mix of projects, the project characteristics, and the project schedules. This kind of approach provides the Naval Material Command with manpower requests that are defensible because they are connected to the programs the Command has been tasked to do.

Another strength of the model is its comprehensive data base. The survey data includes all people supporting the acquisition projects whether they are in the project management office, in the headquarters' support codes, in the field or in the R&D Centers. It accounts for this manpower in a matrix way. Along the side of this matrix are the organizations that supply the manpower support; along the top of the matrix are the projects these people support. Furthermore, and a strength very important in the PPBS, the

model is capable of making consistent multi-year projections. The generation of consistent out-year estimates is difficult to accomplish when the budget is being put together because the budget year takes on overwhelming importance. However, outyear POM numbers have to have some validity because OP-01, OP-90, NAVCOMP, and OSD in particular try to enforce consistency from POM to budget. Another strength of the model is that it is supported by flexible computer software. The advantage of this is that reports can be changed as the Command's information requirements change. The model has the following general limitations.

(1) Only the manpower associated with ship, aircraft, and missile programs is modelled as a function of independent variables; manpower for other acquisition programs and for logistics programs and headquarters functions is throughput (i.e., displayed unaltered as it was input to the model).

(2) The manpower that is modelled is estimated in total (i.e., total civilian, military, and contractor manyears). The model has the capability of displaying a breakout of labor type, but this breakout is based on the historic distribution of some selected historic period. The model does not optimize the distribution of manpower between in-house and contractor sources; nor does it employ any other programmed decision logic to represent interdependencies among these labor types.

(3) The model does not generate estimates of the dollar resources required to fund the computed or displayed manpower projections.

(4) The estimating relationships that were developed for computing manpower projections are based on historic data, i.e., the relationship between descriptors of historic workload (or program) and manning. The model does not compute normative requirements, such as are being developed by the Navy SHORESTAMPS effort. Normative requirements must necessarily be based on a detailed, bottom-up approach; that kind of approach was beyond the scope and contrary to the basic objectives of this study effort.

These limitations are primarily a result of the originally defined scope of the study. Most of them are not permanent and can be overcome by allocating additional effort at expanding the logic and data base of the current, first phase model.

B. SYSTEM DATA REQUIREMENTS

Generally there are two kinds of data that will be required in the future to support the NMC Manpower Requirements Model. First, there is the data which must be collected regularly:

- (1) project characteristics
- (2) project schedules

(3) actual manyears of direct acquisition support specified by system, by functional category, by labor type, by organizational source.

(4) manyears for throughput acquisition projects

(5) manyears for other programs, such as technology base, fleet support, headquarters G&A etc.

These elements are basic recurring inputs to the model and may require revision as external conditions change within the NMC. Also, different values for these elements may be developed to represent alternative programs that might be evaluated during the POM process. It would be desirable to collect this information on a regular, periodic basis.

The second kind of data would be used to refine and update the internal parameters of the model. This includes:

(1) notional manning data

(2) an expanded set of project characteristics data, such as more detailed contracting information, engineering characteristics, or subjectively based descriptors.

These data in conjunction with the first kind would allow revision of the MER coefficients, driver variables, and the notional manning curves. Such revisions would require considerable analysis and would be required only when a sufficient amount of new data becomes available or when it is observed that the basic underlying acquisition process has changed markedly.

C. CONCLUDING REMARKS

This summary has described the NMC Manpower Requirements Model as it presently exists. Although comprehensive in coverage of major acquisition projects, this model is only a tool for performing analysis. To be truly effective, the model must actually be used to support the NMC decision making process.